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Recommended Practices for Soybean Management

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Soybean production depends on numerous environmental variables including rainfall, sunshine, day length, and temperature. They also depend on soils and soil characteristics, which provide nutrients and other inputs to the plants. There are also numerous factors that are controllable, such as: variety selection, tillage, planting date, row spacing, plant population, and nutrients. All of these factors influence where and when soybeans are produced and the regions of the world that produce more soybean than other regions.

Yields

Wheat makes up 28 percent of the world grain crops harvested, followed by corn (26%), rice (19%) and soybeans (6%). Different areas of the world produce different amounts of these crops based on the environmental conditions. In the USA, corn for grain was harvested from 73.0 million acres, soybean from 73.0 million acres, all wheat from 35.0 million acres, and all hay crops from 61.6 million acres in 2000. In Iowa, corn for grain was harvested from 12.0 million acres, soybean from 10.6 and all hay from 1.7 million acres. The USA is the leading soybean producer in the world and contributes about 48 percent of the total world production. Other producers are: Brazil (20%), Argentina (13%), China (9%), India (3%), and Paraguay (2%).

In the United States, 88% of the 1999 soybean crop was produced in 12 Midwest states with Iowa leading the production followed by Illinois, Minnesota, Indiana, Nebraska, Ohio, Missouri, South Dakota, Kansas, Michigan, Wisconsin, and North Dakota. Table 1 lists the acres harvested, yield, and production for the major soybean producing states for 1997, 1998, and 1999.

Iowa produced 18.1 percent of the United States soybean in 1999; but there is considerable variation from one area of the state to another. Table 2 shows the production of the nine districts in Iowa for 1997, 1998, 1999 and 2000. Record yield of 50.5 bushels per acre was produced in 1994.

The highest soybean yields are normally produced in east-central, central, west-central, and northwest Iowa. Most years, the south central, southeast, southwest, and the northeast areas of Iowa produce fewer soybean acres than other regions of the state. However, environmental conditions from year to year significantly influence the average yield of each area of the state.

Table 1. U.S. Acreage, Yield and Production, 1997-1999

State*	Acres harvested (000)			Yield (Bu/acre)			Production (000 Bu)		
	1997	1998	1999	1997	1998	1999	1997	1998	1999
IA	10,400	10,450	10,750	46.0	48.0	44.5	478,400	501,600	478,375
IL	9,950	10,650	10,550	43.0	44.0	42.0	427,850	468,600	443,100
MN	6,550	6,800	6,900	39.0	42.0	41.0	255,450	285,600	282,900
IN	5,300	5,600	5,550	43.5	42.0	39.0	230,550	235,200	216,450
NE	3,550	3,750	4,250	40.5	44.0	42.5	143,775	165,000	180,625
OH	4,340	4,390	4,500	44.0	44.0	36.0	190,960	193,160	162,000
MO	4,850	5,000	5,350	36.0	34.0	27.5	174,600	170,000	147,125
SD	3,250	3,420	4,070	35.0	39.0	36.0	113,750	133,380	146,520
AR	3,550	3,400	3,350	30.5	25.0	28.0	109,800	85,000	93,800
KS	2,350	2,500	2,800	37.0	30.0	28.0	86,950	75,000	78,400
MI	1,860	1,890	1,940	38.5	39.0	40.0	71,610	73,710	77,600
WI	1,000	1,100	1,300	44.0	47.0	46.0	44,000	51,700	59,800
ND	1,140	1,525	1,340	29.5	32.0	35.0	33,630	48,800	46,900
MS	2,070	2,000	1,900	31.0	24.0	23.5	64,170	48,000	44,650
Total US	69,110	70,811	72,476	38.9	38.9	36.5	2,688,750	2,756,794	2,642,908

*Ranked by 1999 production. Source: USDA/NASS.

Table 2. Soybean Acreage (million acres) and Yield (Bu/A) in Iowa by Region

District	1997		1998		1999		2000	
	Acres harvested	Yield	Acres harvested	Yield	Acres harvested	Yield	Acres harvested	Yield
NW	1.71	46.8	1.70	49.3	1.74	47.1	1.72	45.0
NC	1.46	44.2	1.49	48.8	1.53	42.9	1.49	45.0
NE	0.86	45.3	0.86	51.4	0.92	49.0	0.91	49.0
WC	1.64	45.1	1.64	44.8	1.67	41.7	1.64	40.0
C	1.57	47.2	1.65	48.7	1.63	46.6	1.61	44.0
EC	0.88	50.9	0.92	53.6	0.98	49.2	0.96	48.0
SW	0.95	45.0	0.93	42.2	0.95	41.2	0.94	42.0
SC	0.52	45.6	0.50	42.7	0.52	39.0	0.51	41.0
SE	0.81	50.3	0.76	48.9	0.80	40.2	0.78	41.0
Total	10.40	46.5	10.45	48.0	10.75	44.5	10.55	44.0

Source: USDA/NASS

Soybean production in the United States and in Iowa has changed over time. Table 3 includes the mean yields since 1970 in five-year averages for acres harvested, yield, and total production. The yield has steadily increased with an all time high in 1994. Steady improvement has been made in yield potential of soybean produced in the United States primarily because of improved genetic development and better management. Table 4 provides data for Iowa.

Table 3. U.S. Soybean Production, 1970-1999

Crop years	Acres harvested	Avg. yield per acre	Production
	(million acres)	(bu)	(million bu)
1970-74	47.5	26.7	1,267.5
1975-79	59.0	29.4	1,746.7
1980-84	66.4	28.5	1,894.7
1985-89	58.8	32.1	1,890.4
1990-94	58.2	36.0	2,097.6
1995-99	67.8	37.3	2,533.4

Source: USDA/NASS.

Table 4. Iowa Soybean Production, 1970-1999

Crop years	Acres harvested	Avg. yield per acre	Production
	(million acres)	(bu)	(million bu)
1970-74	6.4	32.6	207.7
1975-79	7.2	35.1	255.6
1980-84	8.2	36.3	298.0
1985-89	8.2	38.6	315.6
1990-94	8.4	41.6	347.4
1995-99	10.1	44.8	450.7

Source: USDA/NASS

Tillage

Various types of tillage have been used in soybean production, but in recent years there has been a higher percent of reduced tillage and no-till planting systems. Table 5 provides the percent of soybean planted into different tillage systems.

Table 5. Percent of Full-Season Soybean Acres Planted into Different Tillage Systems in 1998

	Tillage systems				
State	No-till	Ridge till	Mulch till	Reduced till	Conventional till
IA	22	<1	46	22	9
IL	36	<1	20	25	18
IN	54	<1	14	12	18
KS	20	1	16	33	30
MN	8	1	29	29	33
MO	36	<1	20	22	21
NE	24	6	31	25	13
OH	58	<1	8	7	27
SD	26	1	25	28	20
WI	32	<1	22	20	26
Average	28	<1	23	22	26

Source: Conservation Technology Information Center.

About 22 percent of the soybean acres planted in Iowa during 1998 were no-till acres. One reason no-till acreage has increased dramatically in the last few years is that machines have been improved for more precision in depth of planting and spacing between plants. The newer soybean drills and planter provide more accuracy than in the past. Intensive tillage is becoming less popular because of compliance with federal regulations for water quality in order to participate in government programs. The amount of tillage done in the fall on Midwest farms is directly related to the amount of time between harvest and the onset of winter weather.

Soybeans loosen the soil as they grow because of their extensive branched taproot. Although this has a positive effect on soil tilth, greater soil erosion will occur if the topography is sloping. Generally speaking, soil erosion loss during or following soybean production is greater than with corn.

Varieties

In 1999 Iowa Crop Performance Test – Soybeans program evaluated more than 800 entries for yield, maturity, height, lodging, emergence, and other variables. These tests are conducted in three districts of Iowa: northern, central, and southern. Entries are evaluated at three locations in each district and the variety trials are replicated at each location. The annual report gives details on comparison of the entries, which were evaluated. Roundup® Ready varieties were first evaluated in a special test during 1998. Other states have similar variety tests, but few states evaluate as many entries as Iowa.

Of the 851 entries, 37 of the entries were from public institutions. The other 814 entries were submitted for testing by 58 private companies. The range of varieties for the producer to select from is tremendous in the Midwest. The genetic improvement of these varieties has steadily increased the yield potential.

The 1999 Iowa Crop Performance Test – Soybeans includes one-year data, two-year averages, and three-year averages. About half of the entries only have one year of data available because many commercial companies do not choose to enter some varieties more than one year. It is risky for a producer to select varieties based on one year's data because the environmental conditions the following year will likely not be identical to the year reported. Therefore, it is much safer to base the variety selection on a two- or three-year average. The range in yield among entries may be more than 10 bushel per acre. Popular varieties from several years ago yield 10 to 20 bushel less than the best new varieties entered in the test.

Soybean variety plant height is also reported and there will be several inches variation among the different varieties. Frequently, higher lodging scores are associated with taller varieties. Nearly all the varieties tested will be of the indeterminate type, which is most popular in the Midwest. There may be a few determinate growth type entries, which will be shorter in plant height and are frequently recommended for planting at higher plant populations. Iron chlorosis, which is an iron deficiency symptom, often occurs in naturally high lime soils in central and north-central Iowa and southern Minnesota. Varieties have been developed that are somewhat tolerant to iron chlorosis and will survive under high lime soil conditions better than other varieties. Therefore, producers in areas with high lime soils frequently will select specific varieties with acceptable iron chlorosis scores for their production.

Also included are ratings for phytophthora and cyst nematodes; ratings will indicate the susceptibility or resistance to these diseases. Protein and oil scores are also available and the protein range is usually from 32 to 39 percent. The oil content of soybean grown in Iowa will range from 14 to 20 percent oil.

Row Spacing

Past research has shown that narrow rows normally produced higher soybean yields than wide rows in most environments. More than 40% of the soybeans are planted in 30-inch rows in Iowa but there is an increasing number of producers that are using narrow and intermediate row technology. Table 6 illustrates the percent of soybean planted at different row spacing in Iowa, Illinois, Minnesota, and Missouri.

Intermediate row spacing have recently gaining popularity throughout the Midwest with the introduction of new planter equipment with 15" and 30" row capability on the same equipment. Recent studies in Iowa have provided mixed results about yield of different row spacing. In some environments wide rows yield best and the same for intermediate rows. During a 3-year study across five locations, four locations had a significantly higher yield when grown in 15" rows.

Table 6. Soybean Row Spacing as Percent of Total

State	Year	Row Spacing (inches)				
		<10	10.1-18.5	18.6-28.5	28.6-34.5	>34.5
		percent of samples				
Iowa	1994	28.3	9.9	6.0	44.2	11.6
	1995	28.2	10.5	5.6	40.4	15.3
	1996	28.3	12.3	5.1	42.2	12.1
	1997	25.1	19.2	4.0	42.0	9.7
	1998	21.7	22.1	7.1	41.0	8.1
	1999	18.4	25.7	7.4	41.8	6.7
Illinois	1994	45.6	11.4	3.0	34.6	5.4
	1995	57.1	10.1	2.9	26.0	3.9
	1996	53.2	15.2	2.2	25.5	3.9
	1997	55.2	18.5	3.1	21.1	2.1
	1998	54.5	17.8	2.0	22.0	3.7
	1999	44.3	31.6	3.0	16.5	4.6
Minnesota	1994	36.2	12.4	6.9	35.6	8.9
	1995	25.0	14.3	9.7	46.4	4.6
	1996	30.8	11.9	10.5	38.8	8.0
	1997	27.8	28.9	5.1	36.1	2.1
	1998	17.6	21.0	15.7	43.8	1.9
	1999	22.1	26.1	12.1	33.7	6.0
Missouri	1994	46.4	15.0	6.0	23.3	9.3
	1995	53.1	14.0	5.7	22.3	4.9
	1996	48.4	19.2	4.4	20.4	7.6
	1997	47.3	30.1	5.0	11.7	5.9
	1998	49.6	26.4	3.6	14.0	6.4
	1999	40.9	34.1	6.7	14.3	4.0

Source: USDA/NASS.

Table 7. Soybean row spacing effect on yield in Iowa (1997-99)

Location	Row spacing	
	15-inch	30-inch
	- bushels/acre -	
Northwest	53.1	50.6
Northeast	60.7	57.7
Central	49.1	46.9
Southwest *	62.5	62.1
Southeast	51.8	50.5

* Southwest was the only site that didn't have significant difference between the yield of the two row widths at the 0.05 level.

Plant Population

The soybean plant will adapt to a wide range of plant densities by increasing the number of branches if the population is low and producing fewer branches if the population is high. Table 8 provides information on row spacing and harvest population to maximize grain yield in Iowa. The competition for light, nutrients, and moisture between plants is much greater in wider rows than narrow rows. These studies have indicated that high plant populations may not be necessary to maximize yield. Studies conducted in narrow rows with no-till management have shown that most soybean fields will maximize yield with less than 130,000 plants per acre (PPA) at harvest.

Table 8. Effect of Row Spacing and Harvest Stand on Soybean Yield at Five Locations in Iowa, 1994-1996

Plant stand target	Narrow rows (7.5 & 10 inches)		Wide rows (30 inches)	
	Harvest stand	Grain yield (Bu/acre)	Harvest stand	Grain yield (Bu/acre)
80,000	94,000	47.9	73,000	46.3
120,000	133,000	50.2*	110,000	49.3*
160,000	157,000	50.9*	135,000	49.8*
200,000	186,000	51.6*	165,000	50.6*
240,000	221,000	51.4*	189,000	49.8*

*Yields followed by (*) are statistically similar.

Seed cost is another consideration when determining optimum harvest populations for high yield. Seed cost for 150,000 seeds per acre will range from $10.00 to $36.00, depending on seed size and cost of seed.

Table 9 shows a range of seed sizes and cost per 50 lb. bag, with the cost of 150,000 seeds calculated for each combination. Seed cost is not high compared to herbicide and other costs in soybean production, but a few dollars saved can be important. If the producer can attain high grain yield by harvesting between 110,000 and 140,000 PPA, then it should not be necessary to plant 200,000 or more seeds per acre at planting.

Table 9. Seed Cost for 150,000 Seeds/acre with Different Seed Sizes and Costs/bag

Seed size	Price of 50-pound bag of seed					
(seeds/lb)	$14	$16	$18	$20	$22	$24
	Cost ($) of seed to plant 150,000 seeds/acre					
2,000	21.00	24.00	27.00	30.00	33.00	36.00
2,500	16.80	19.20	21.60	24.00	26.40	28.80
3,000	14.00	16.00	18.00	20.00	22.00	24.00
3,500	12.01	13.73	15.44	17.16	18.88	20.59
4,000	10.50	12.00	13.50	15.00	16.50	18.00

Table 10. Seed Required for Three Seeding Rates and Different Seed Sizes

Seed size (seeds/lb.)	Seeds per 50 lb. bag	Seeding rate per acre		
		150,000	175,000	200,000
		(pounds of seed per acre)		
2,000	100,000	75.0	87.5	100.0
2,250	112,500	66.7	77.8	88.9
2,500	125,000	60.0	70.0	80.0
2,750	137,500	54.6	63.6	72.7
3,000	150,000	50.0	58.3	66.7
3,250	162,500	46.2	53.9	61.5
3,500	175,000	42.9	50.0	57.1
3,750	187,500	40.0	46.7	53.3
4,000	200,000	37.5	43.8	50.0

The table 10 illustrates how seed cost can be reduced without reducing the seeding rate. A 100-acre field is to be planted to a variety that has 3,000 seeds per pound (compared to 2,500 seeds per pound). More seeds per pound results in fewer pounds of seed needed to maintain the desired seeding rate. Using a rate of 175,000 seeds per acre, a producer can save 12 pounds by using the smaller seed (58 pounds versus 70) per acre, or 24 bags over 100 acres (1,200 pounds over 100 acres/50 pounds per bag). If seed costs $20 per bag, the producer saves $480 over 100 acres. Table 11 provides information on soybean seeding rates and costs in 1994 for several states in the

Midwest. Seeding rate varies with environments, and Ohio, Nebraska, and Indiana, plant at the highest seeding rate of the states reported. Seed costs vary depending upon availability and transportation costs. Iowa producers purchase more seed than other states, with Missouri having the lowest percentage. Seed treated with a pesticide to help control diseases during emergence will vary considerably, from a low of nine percent in Minnesota to a high of thirty-five percent in Ohio. The Ohio environments normally receive more rainfall and, therefore, have more seedling diseases than in drier areas of the country. Some commercial companies pre-treat seed with fungicides, but most do not. Fungicide treatment is recommended if the field has a history of seedling diseases and if conditions favor rapid development of pests.

Table 11. Soybean Seeding Rates and Costs - 1994

State	Acres planted (million)	Rate/acre (pounds)	Cost/acre ($)	Acres with purchased seed (%)	Seed treated with pesticide (%)
Iowa	8.8	65	17.30	82	15
Illinois	9.6	69	17.84	73	20
Minnesota	5.7	70	16.57	71	9
Indiana	4.7	74	17.73	75	22
Ohio	4.0	82	18.00	68	35
Missouri	4.6	69	15.65	55	20
Nebraska	2.9	75	20.21	76	23
1994 Total	43.8	69	17.25	72	21
1993 Total	42.5	69	16.29	73	NA
1992 Total	48.6	65	15.40	73	NA

Source: USDA/NASS.

Planting Dates

Table 12 is a summary of data collected over three years at five locations in Iowa. The highest yields were produced when the soybean crop was planted late April or early May. However, yields were not significantly different when planted between late-April and mid-May. Later planting dates resulted in significantly lower yields. With late planting of soybean or replanting after the middle of June or early July, it is recommended that narrow rows be used. The plant population should also be increased as much as 20,000 to 30,000 plants per acre. Soybean planted in late June will flower in fewer days because of the critical day length, which triggers the flowering mechanism. Therefore, flowering will begin while the plants are smaller, resulting in shorter plant height with later planting. Higher plant populations will help compensate by producing additional sites for pod development. Early planting usually results in higher yield, but soil conditions must be appropriate before any planting is done.

Table 12. Effect of Planting Date on Soybean Yield in Iowa (1994-96)

Average Planting date	Northern Iowa	Central Iowa	Southern Iowa
	(Percent of maximum yield)		
Late April	100*	96*	98*
Early May	96*	100*	100*
Mid-May	99*	96*	98*
Early June	81	93	89
Mid-June	61	59	82
Early July	33	45	47

*Yields are statistically similar.